ED_000545A_00004824

EPAct Program Update for Chet France

January 23, 2008

Preliminary information – not for release outside EPA

Light Duty Exhaust Program Overview

- EPA/DOE collaboration
- Objective: Establish effects of RVP,T50,T90, aromatic content and EtOH on exhaust emissions from Tier 2 vehicles
- Fuel matrix includes 29 fuels + 2 added by CRC = total of 31
- Test Program Design
  - Phase 1: RFS 2 Pilot at 75°F
    - 3 fuels (E0, E10 and E15) tested in 19 vehicles
    - Test results to be available for RFS 2 NPRM
  - Phase 2: RFS 2 Pilot at 50°F
    - Same as Phase 1, except temperature
  - Phase 3: Main Program
    - 27 fuels tested in 19 Tier 2 vehicles, E85 tested in 4 FFVs
- LA92 test cycle used throughout the program
- Species measured: Regulated emissions, CO_2, NO_2, VOCs, ethanol, carbonyl compounds
  - N_2O, NH_3 and HCN by FTIR
  - Some PM and SVOC speciation

Status of Testing

- Phase 1 testing complete
  - 75F testing of 19 vehicles on 3 fuels (E0, E10, E15)
  - Data was received by EPA, briefing materials were presented on primary findings
- Interim FTP-cycle testing complete
  - 75F testing of 6 vehicles on 3 fuels (E0, E10, E15)
  - Data was received by EPA, this briefing contains primary findings
- Phase 2 testing underway
  - 50F testing of 19 vehicles on 3 fuels (E0, E10, E15)
  - Fuel 17 and 18 testing were recently completed
  - Fuel 19 testing has begun, to be completed by 2/6
  - Data is being processed at SWRI and here
- Phase 3 testing expected to begin mid-February

Revised EPAct Fuel Matrix

Phase 3
Base Program (EPA)
(Fuels 1-16) →

Phases 1 and 2
RFS 2 Subset (EPA/DOE)
(Fuels 17-19) →

Phase 3
Additional Fuels (DOE)
(Fuels 20-29) →

E85 (DOE) →

CRC Additional Fuels →

Fuel #	T50 °F	T90 °F	ETOH %	RVP psi	ARO %
1	150	300	10	10	15
2	240	340	0	10	15
3	220	300	10	7	15
4	220	340	10	10	15
5	240	300	0	7	40
6	190	340	10	7	15
7	190	300	0	7	15
8	220	300	0	10	15
9	190	340	0	10	40
10	220	340	10	7	40
11	190	300	10	10	40
12	150	340	10	10	40
13	220	340	0	7	40
14	190	340	0	7	15
15	190	300	0	10	40
16	220	300	10	7	40
17	215	325	0	9	30
18	202	325	10	9	25
19	195	325	15	9	23
20	160	300	20	7	15
21	160	300	20	7	40
22	160	300	20	10	15
23	160	340	20	7	15
24	160	340	20	10	15
25	160	340	20	10	40
26	150	340	15	10	40
27	190	340	15	7	15
28	190	300	15	7	40
29	TBD	TBD	85	TBD	TBD
30	150	325	10	10	40
31	160	325	20	10	15

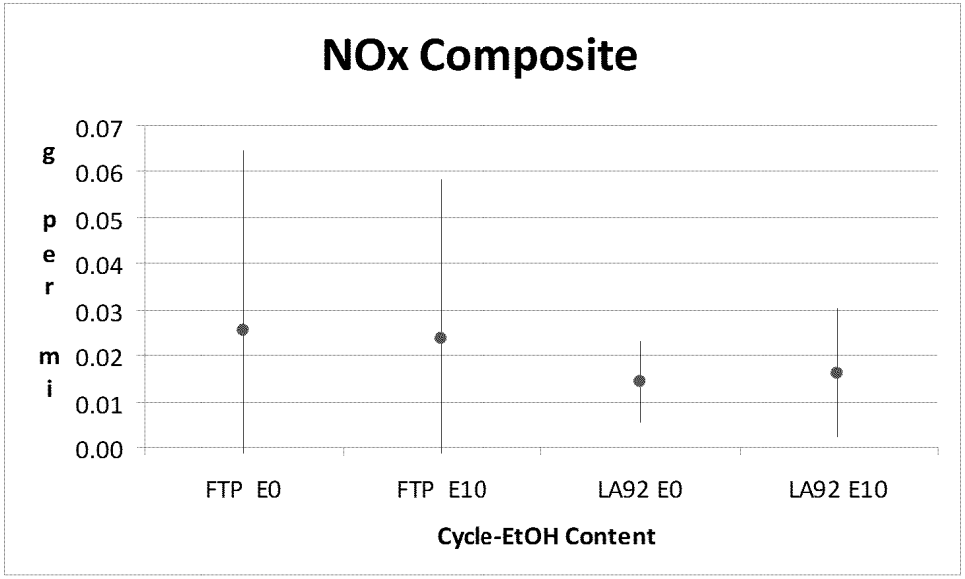
Revised Fuels

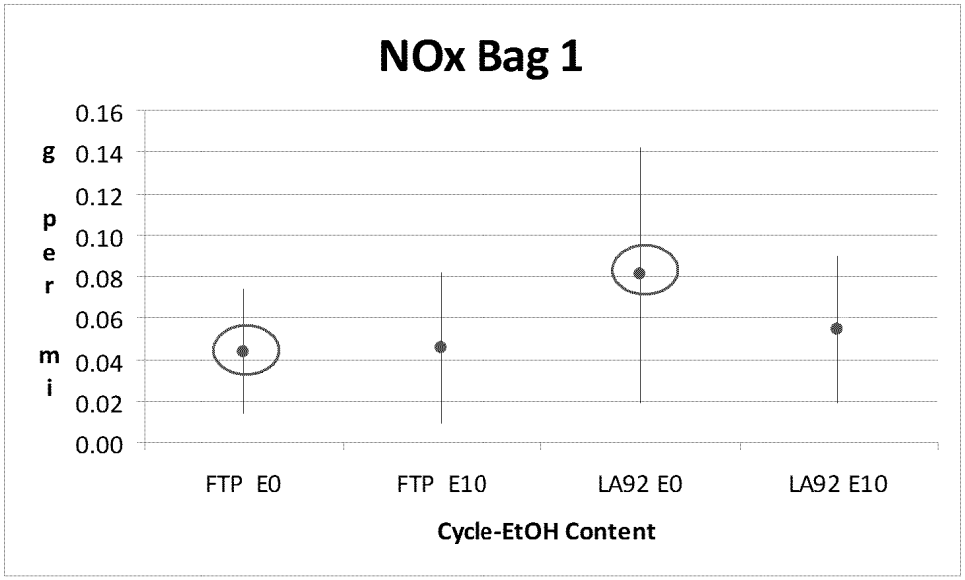
Fuel Blending Is On-Schedule

- Test fuel development being done cooperatively by Haltermann and ASD
  - EPA defines fuel recipes
  - Haltermann prepares hand blends, bulk blends and performs fuel analyses
- 16 of the 28 fuels needed in Phase 3 have been or are being blended in bulk
  - 8 have been delivered to SWRI
  - E85 fuel will be obtained from CRC
- The remaining 12 fuels are in hand blend stage
- We expect to have all fuels blended in bulk by mid-February
- This will allow randomization of fuels for Phase 3, as planned

Preliminary Findings on Effect of Test Cycle - NOx

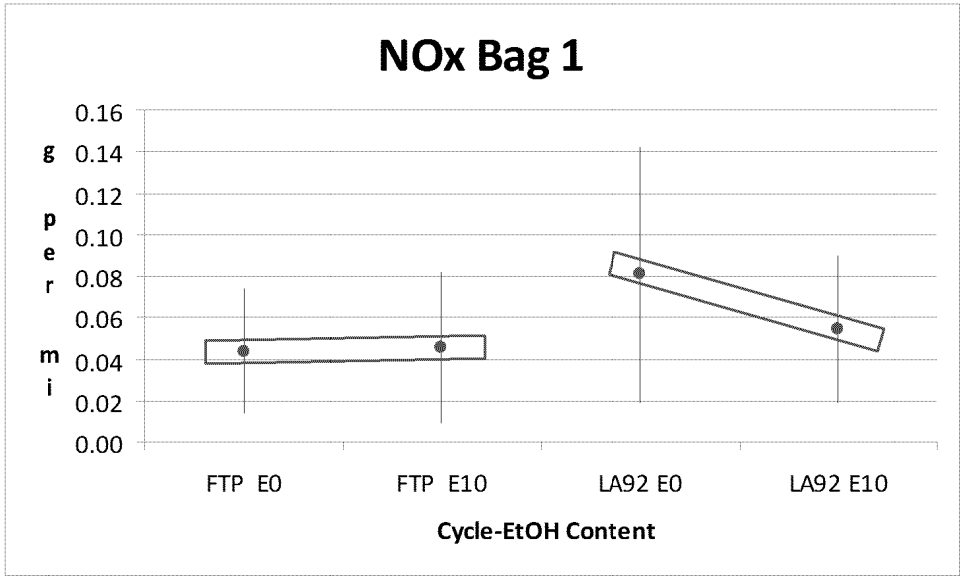
- Results suggest no significant NOx effect or interaction in the composite
- Only significant finding was in Bag 1:
  - LA92 > FTP on E0
  - *This finding could be a primary driver of our results*
- Note: Statistical significance in these slides is $p<0.05$ level
  - Things within a colored circle are significantly different from things within a different circle of the same color





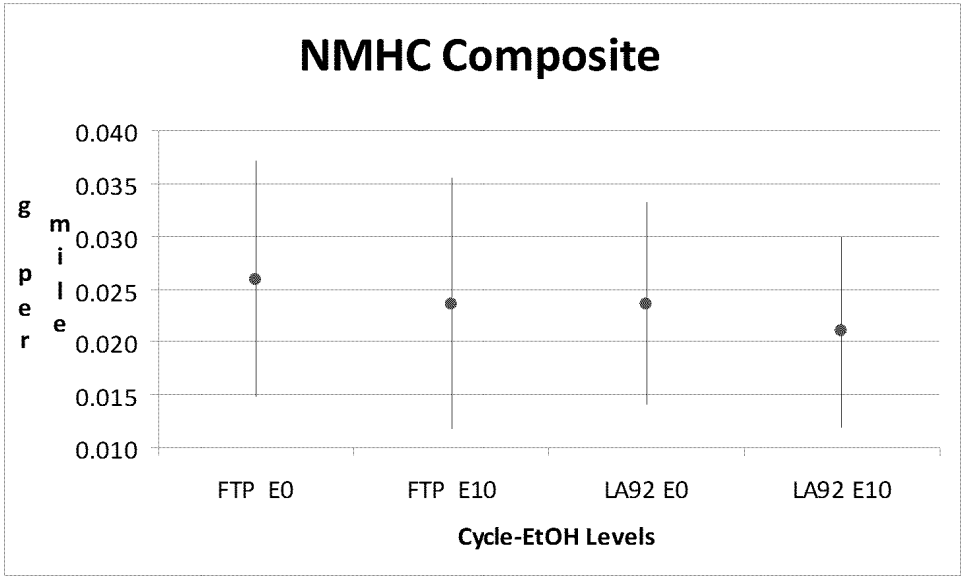
A Few Words About the Cycle Results

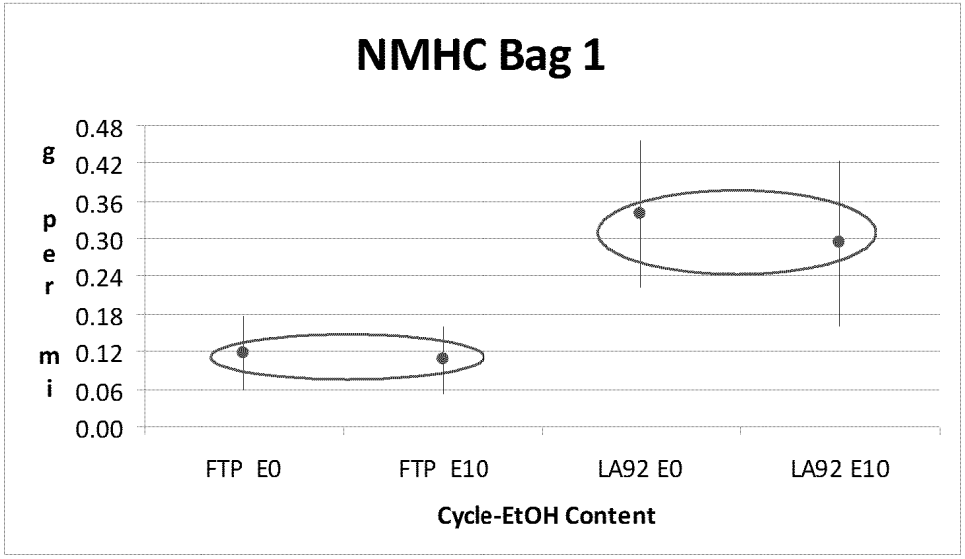
- What question were we trying to answer with this FTP testing?
  - "*Were the effects of ethanol seen in Phase 1 a result of Tier 2 vehicles actually behaving differently from older vehicles, or just an artifact of the LA92 test cycle we chose?*" (Focusing primarily on NOx)
- Did we answer this? What were we looking for in the data?
  - The means appear to suggest E10 may show more favorable effects on cold start NOx emissions with LA92, but deltas are not statistically significant
  - Thus, for now we conclude test cycle was not (highly) influential on NOx results
- Conclusions about test cycle effects were more tenuous than conclusions drawn in Phase 1 about ethanol effects in general, because only six vehicles were tested on FTP cycle



Preliminary Findings on Effect of Test Cycle - NMHC

- Results suggest no significant NMHC effect or interaction in the composite
- Some significant effects were seen in Bags 1 & 3:
  - Bag 1: LA92 > FTP for both levels of ethanol
  - Bag 3: LA92 > FTP for E0

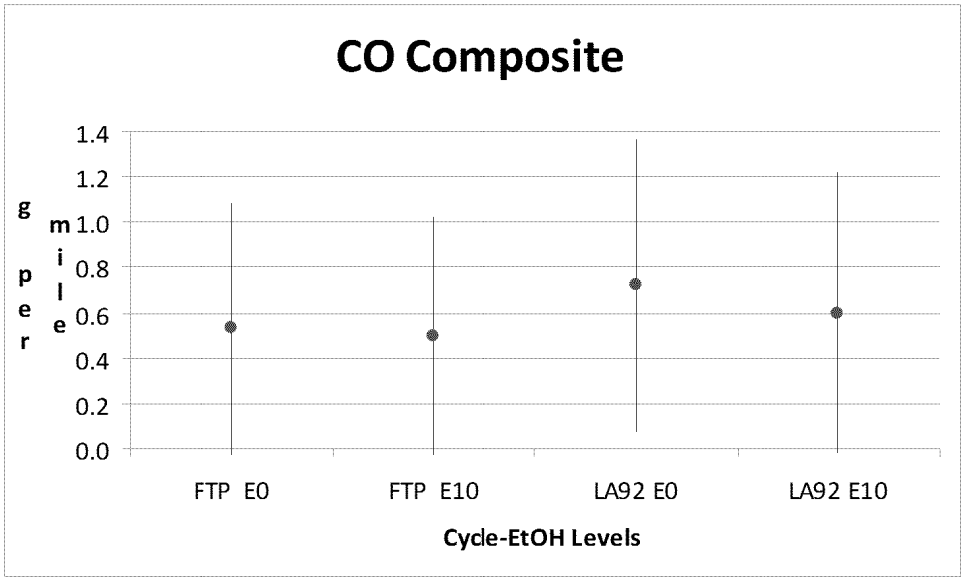


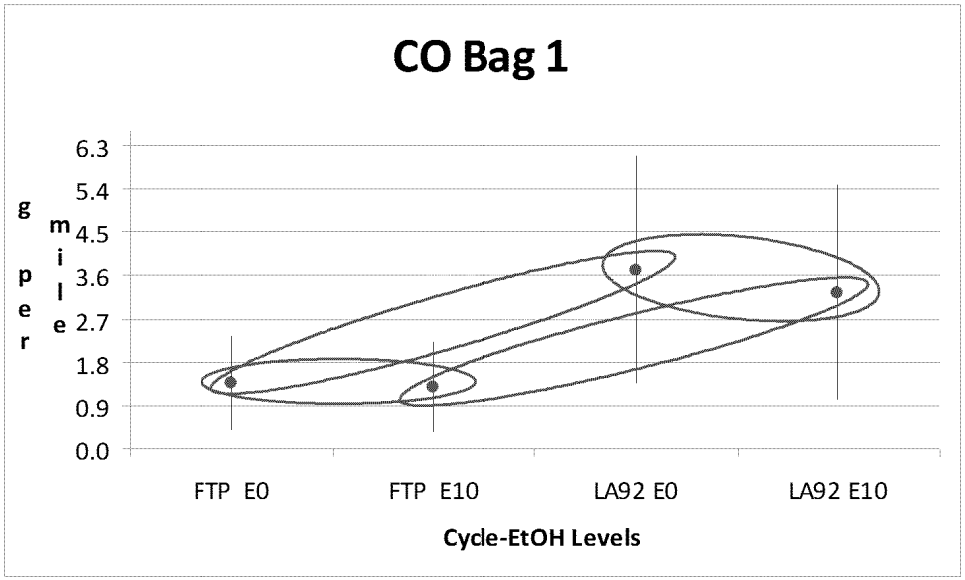


Preliminary Findings on Effect of Test Cycle - CO

- Results suggest no significant CO effect or interaction in the composite

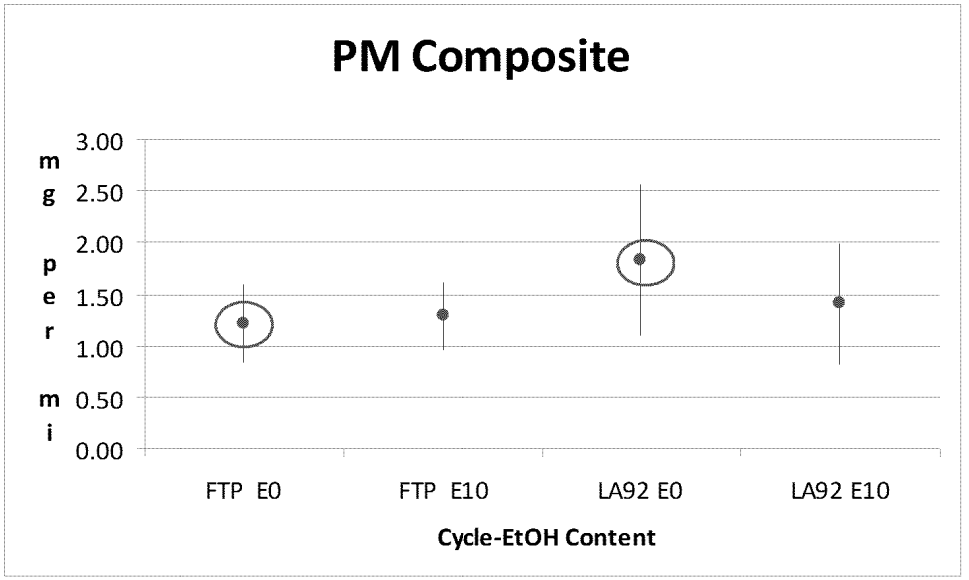
- Some significant effects seen elsewhere:
  - Bag 1: LA92 > FTP for both levels of ethanol
  - Bag 1: E0 > E10 for both cycles
  - Bag 2: LA92 > FTP for both levels of ethanol
  - Bag 3: E0 > E10 for LA92
  - Bag 3: LA92 > FTP for E10

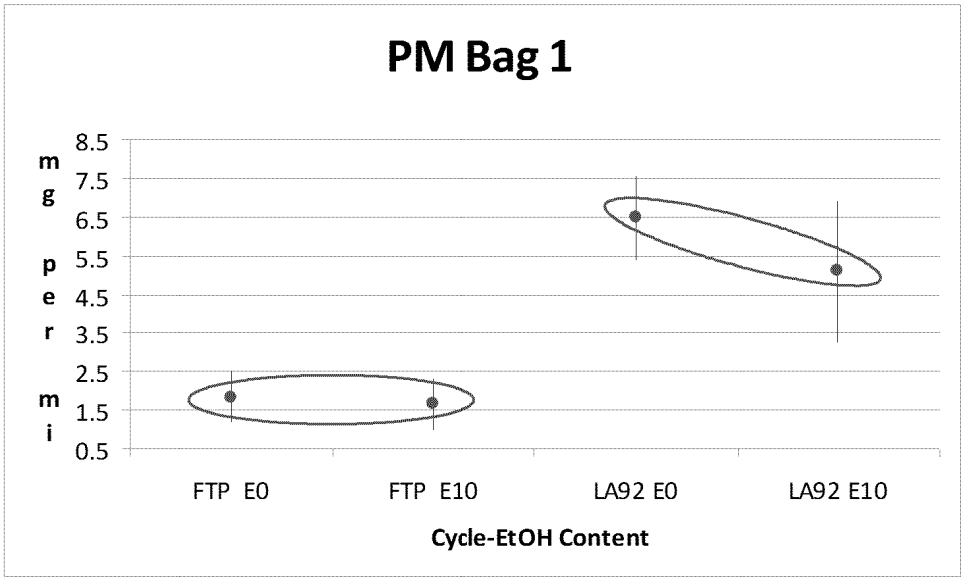




Preliminary Findings on Effect of Test Cycle - PM

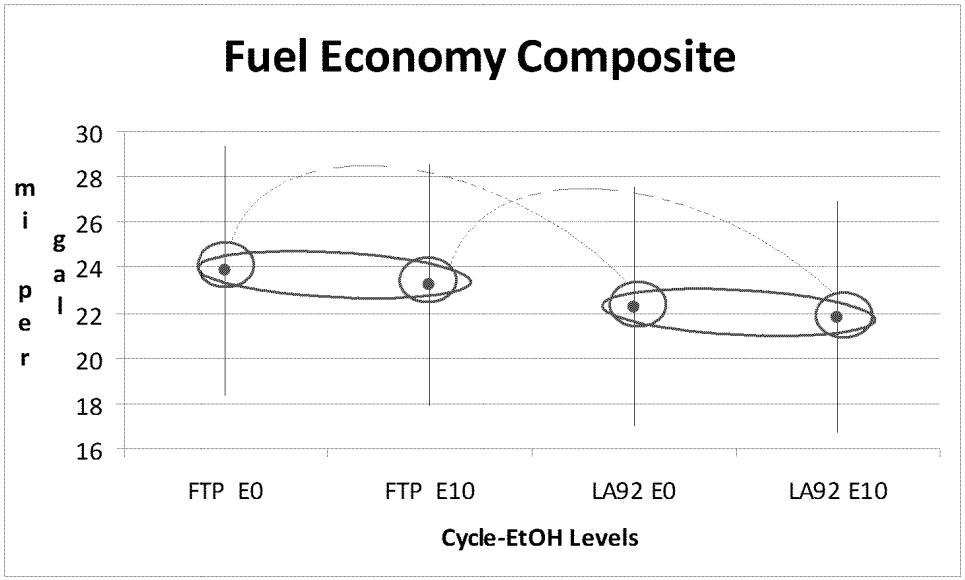
- Significant cycle effects in composite, with ethanol interaction:
  - LA92 > FTP for E0
- Significant cycle effects in Bags 1 & 3:
  - Bag 1: LA92 > FTP for both ethanol levels
  - Bag 3: LA92 > FTP for both ethanol levels

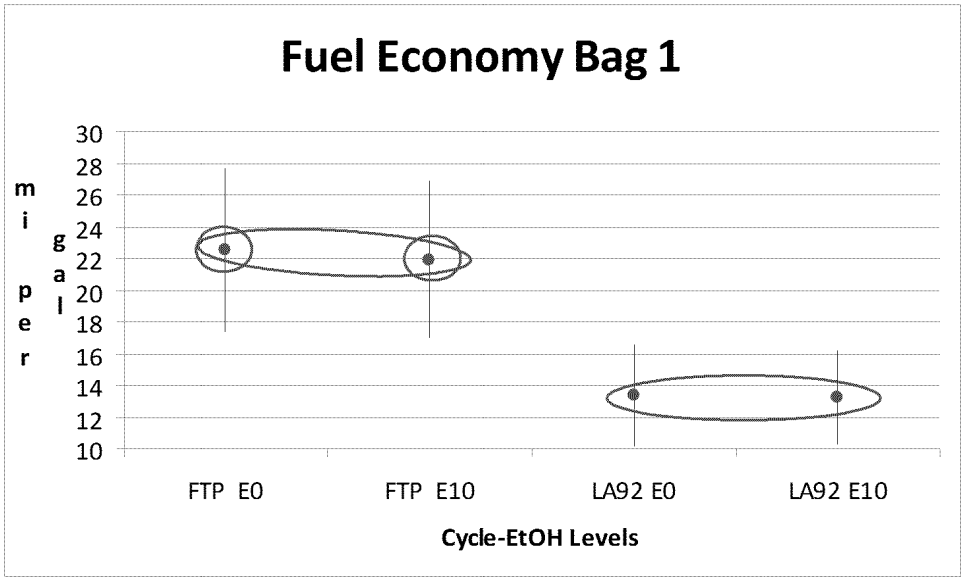




Preliminary Findings on Effect of Test Cycle - FE

- Significant cycle and ethanol effects in composite, with some interaction:
  - FTP > LA92 at both ethanol levels
  - E0 > E10 for both cycles
- Lots of ethanol-cycle interactions in individual bags
- Two interesting findings:
  - In all bags, FTP appears to highlight ethanol FE difference more than LA92
  - In Bag 2, LA92 appears to have equal or slightly better FE than FTP (reverse of other bags & composite)





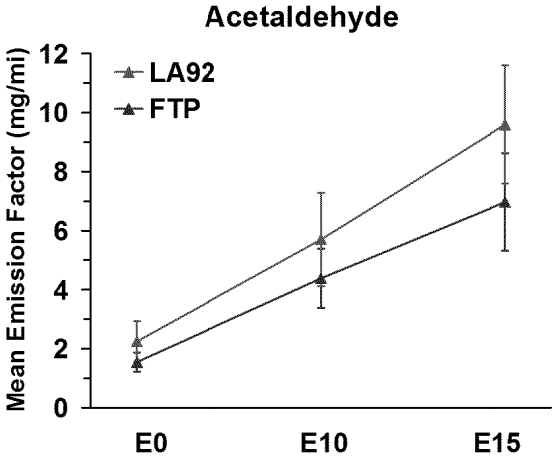
Air Toxics Summary: Phase I and Test Cycle Effects

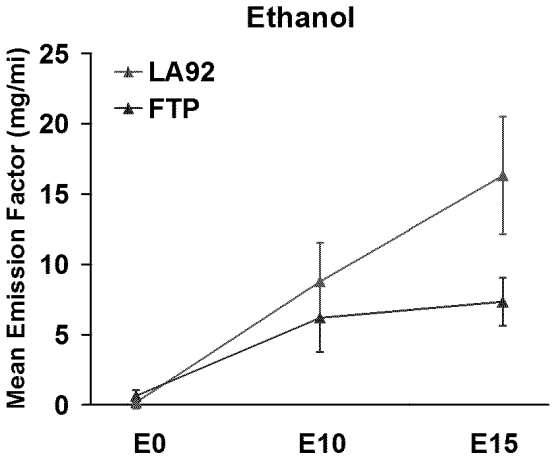
Phase I Results:

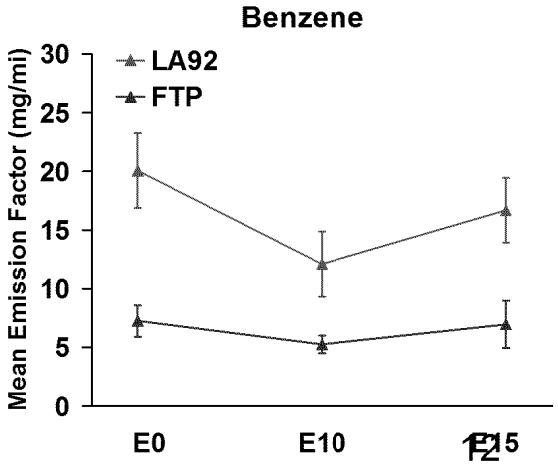
- Overall, emission factors for air toxics are very low.
- Trends for some individual toxics are as expected:
  - Acetaldehyde and ethanol emissions increase with increasing ethanol in fuel.
- Fuel content irregularities obscure trends for some VOCs, including benzene. This will impact Phase II results as well.

Test Cycle Effects:

- Bag 1 data only: Nothing unexpected in trends for individual toxics.
- Cannot conclude that test cycle has an effect.

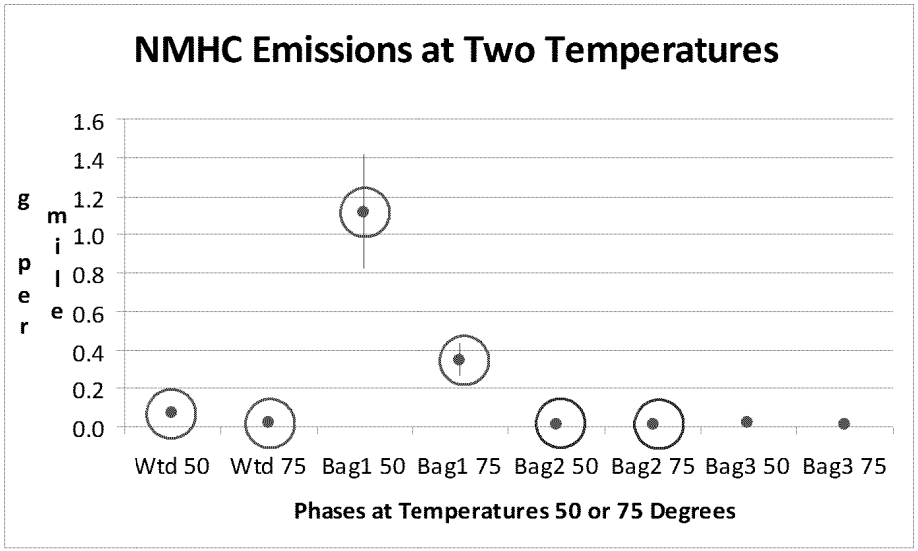


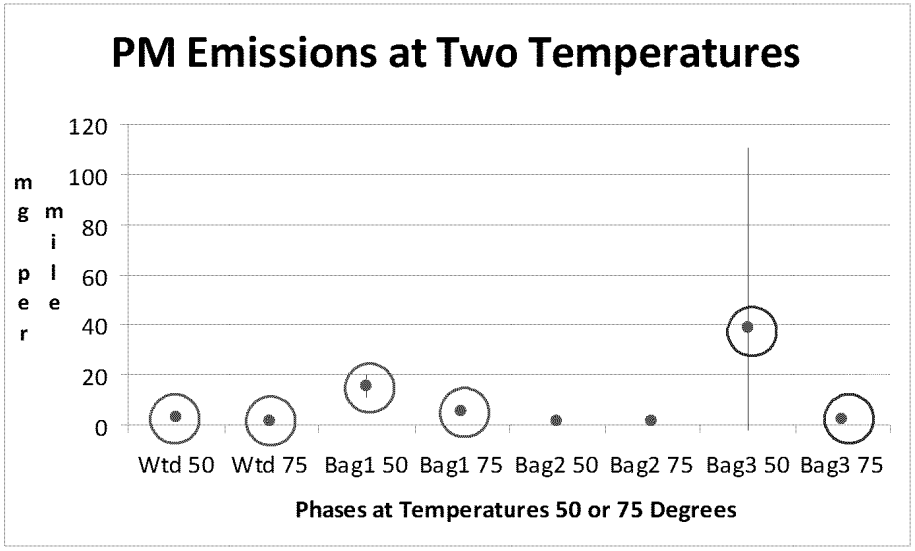


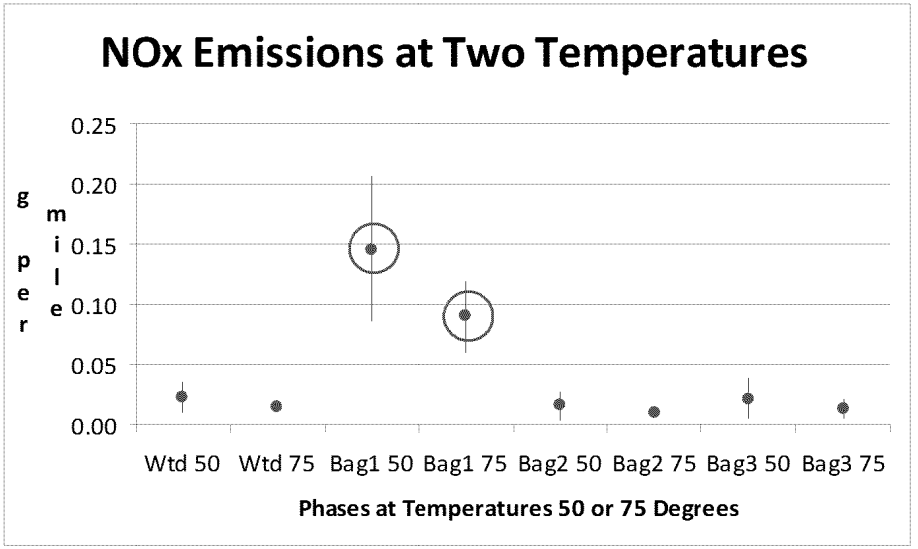


Preliminary Findings on Effect of Test Temperature

- As expected, lower temperature caused emission increases in most cases
  - Colored circle pairs indicate significant differences
- E10 & E15 data still being collected







Budget Considerations Going Forward

- Original program cost estimate: $4,271,000
- Current cost overrun wrt the original scope of program: Ex. 4 - CBI
- Cost overrun including additional projects: Ex. 4 - CBI
- ASD staff have worked hard with SwRI to reduce costs while still keeping the program intact

	Program or Project	Cost	Cumulative Cost	Difference of Total From the Original Estimate of $4,271,000	
ORIGINAL PROGRAM	EPAct Program, April 2008 Cost Estimate	$ 4,271,000	-	-	-
	EPAct Program, January 2009 Cost Estimate	$ 4,698,100	Ex. 4 - CBI		
	Fuel Cost Adjustment	Ex. 4 - CBI			
ADDITIONAL PROJECT	FTP Testing (Partially Competed)				
	EFM Resolution (Completed)				
	Fuel Matrix Redesign (Completed)				
	Blending of Two CRC Fuels				
	EmissionTesting of Two CRC Fuels				

Budget Considerations Going Forward (Cont'd)

- Phase 3 cost estimate: $1,860,000
- Current shortfall: $1,204,500

	Program or Project	Date Estimated	Cost Estimated	Cost Actual	Cumulative Cost	Difference of Total From the Original Estimate of $4,271,000		Comments
ORIGINAL PROGRAM	Whole EPAct Program	29-Apr-08 6-Jan-09	$ 4,271,000 $ 4,698,100	-	-	-	-	Ex. 4 - CBI
	Phase 1 (Completed)							
	Phase 2 (Compl. Feb 2009)	Jul-08 7-Jan-09						Ex. 4 - CBI
	Phase 3 (Starts Feb 09)	7-Jan-09						
	Fuel Cost	8-Dec-08						
	Fuel Cost Adjustment	7-Jan-09						uel cost adjustment related to reblending of one fuel, some stranded fuel development work y Haltermann and EPA involvement in test fuel development
ADDITIONAL PROJECT	FTP Testing (Partially Competed)	7-Jan-09						Additional test program to compare LA-92 and FTP tests wrt ethanol mpacts
	EFM Resolution (Completed)	7-Jul-08						Additional program to enable the use of the Sensors exhaust flowmeter in he EPAct Program
	Fuel Matrix Redesign (Completed)	1-Jul-08						Statistical redesign of the fuel matrix
	Blending of Two CRC Fuels	7-Jan-09						Exchange with CRC
	Emission Testing of Two CRC Fuels	7-Jan-09						Exchange with CRC
				Grand Total >>>	$ 5,475,500	$ 1,204,500	28.2%	

Ex. 4 - CBI

Projected Schedule Going Forward

- Launch of Phase 3 testing: Mid-February 2009
- Completion of Phase 3 testing: Early December 2009
- Reporting: December 2009 – mid-March 2010

		JAN 2009				FEB 2009				MAR 2009					APR 2009				MAY 2009				JUN 2009					JUL 2009				AUG 2009					SEP 2009				OCT 2009				NOV 2009					DEC 2009			
		5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21	28
Phase 1[a]	14 weeks																																																			
50F setup	3 weeks																																																			
Phase 2[b]	9 weeks	4	5	6	7	8	9																																													
50F teardown	2 weeks																																																			
Phase 3[a]	26 weeks						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26																						
NREL fuels[a]	17 weeks																																1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17				
CRC fuels	4 weeks																																																		1	2	3	
NREL high emitter	2 weeks																																																			
draft final report	6 weeks																																																	1	2	3	
EPA/NREL review	4 weeks																																																			
final report	4 weeks																																																			

		JAN 2010				FEB 2010				MAR 2010					APR 2010				MAY 2010				JUN 2010					JUL 2010				AUG 2010					SEP 2010				OCT 2010				NOV 2010					DEC 2010			
		5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21	28
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final report	4 weeks								1	2	3	4																																								

Summary of Next Steps

- Complete analysis of FTP cycle effect
  - E15 data is still pending
- Complete Phase 2 testing
  - Analyze and present results for E10 and E15 fuels
- Complete fuel blending
- Perform Phase 3 testing

Additional Slides

Measured Species

- Bag (phase) level and composite emissions of THC, NMHC, NMOG, CO, CO_2, NOx, NO_2, ethanol and PM
- Bag (phase) level speciated volatile organic compounds (VOCs)
  - Over 200 compounds, incl. alcohols and carbonyls
- Continuous and integrated by bag (phase) emissions of the following species in raw exhaust:
  - THC, NMHC, CO, CO_2, NOx
  - N_2O, NH_3 and HCN by FTIR for a subset of tests
- Semi-volatile and high molecular weight VOC and PM measured in Phases 1 and 2 only

EPAct Vehicles vs. Tier 2 Emission Standards

EPAct Vehicle	Tier 2 Bin #	NMOG g/mile	CO g/mile	NOx g/mile	PM g/mile
Ford Focus, Ford Explorer	4	0.070	2.1	0.04	0.01
All other EPAct vehicles	5	0.075	3.4	0.05	0.01
Ford F150, Dodge Caravan	8	0.100	3.4	0.14	0.02

E10 Impacts on Emissions from Tier 2 Vehicles

From EPAct Phase 1, 19 Vehicles, Paired t-test, $p<0.05$

Pollutant	Percent Change vs. E0			
	Weighted	Bag 1	Bag 2	Bag 3
NOx	-	-24.8	-	-
THC	-	-6.9	-	-31.2
CO	-17.6	-	-19.9	-41.9
PM	-20.8 ($0.1<p<0.05$)	-	-24.8	44.7

E10 Impacts on Emissions from Tier 2 Vehicles

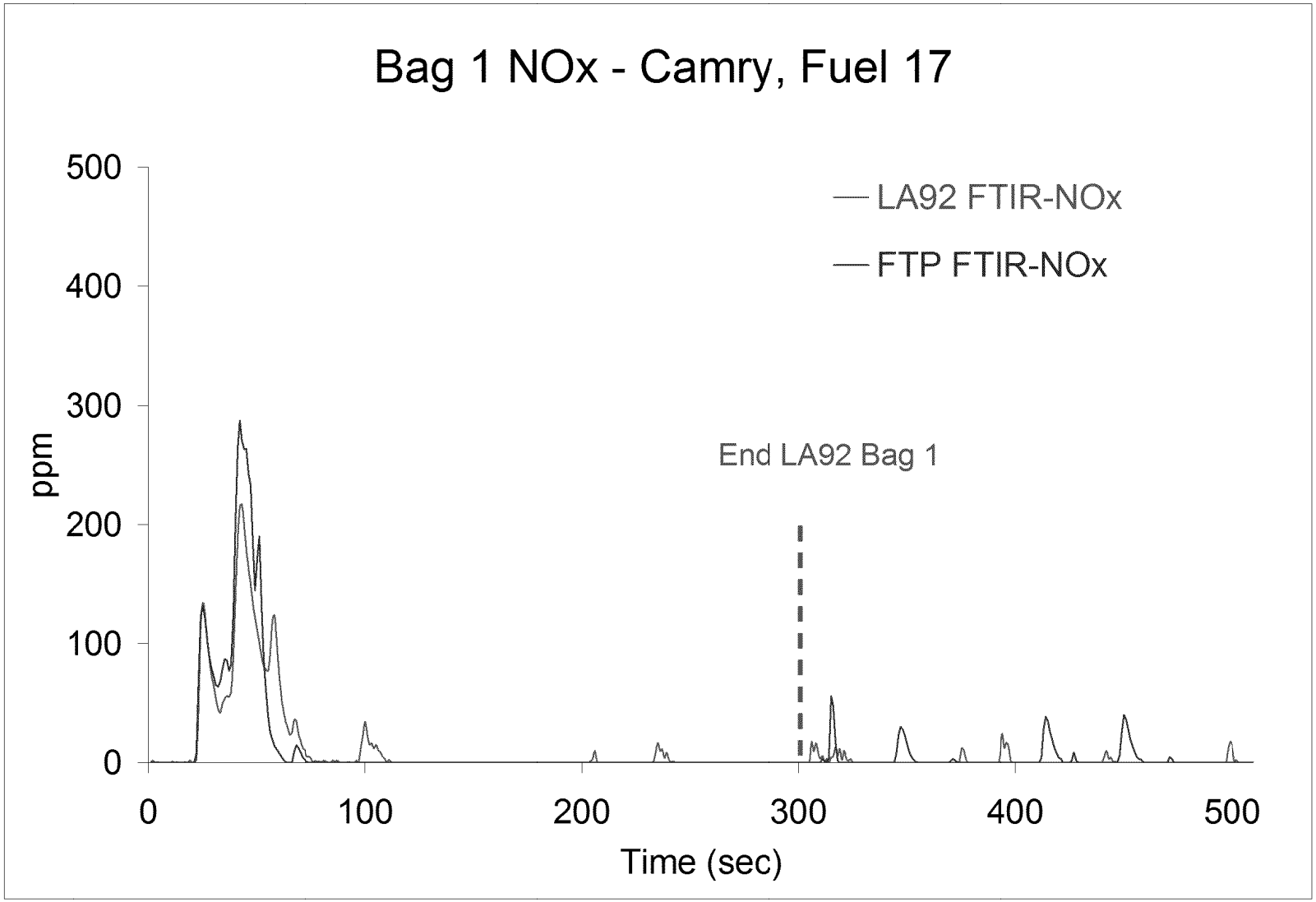
From CRC E-74b Program (7 Vehicles, Mixed Model, $p<0.05$)

Pollutant	Percent Change vs. E0			
	Weighted	Bag 1	Bag 2	Bag 3
NOx	-	-	-	-
NMHC	-12.9 ($0.1<p<0.05$)	-	-	-
CO	-22.4	-22.4	-	-
CO_2	-	-	-	-

Test Fuel Properties

PROPERTY	UNIT	METHOD	FUEL		
			E0	E10	E15
Ethanol Content	vol. %	D5599	<0.1	9.35	14.5
T50	ºF	D86	215	209	182
T90	ºF	D86	324	319	310
RVP	psi	D5191	9.17	9.05	8.91
Aromatics	vol. %	D1319	29.3	22.9	18.7
Olefins	vol. %	D1319	6.4	5.7	5.6
Benzene	vol. %	D3606	0.48	0.49	0.46
S	mg/kg	D5453	23	23	21
RON	-	D2699	93.4	93.7	93.9
MON	-	D2700	83.5	84.9	84.6
(R + M)/2	-	Calc.	88.5	89.3	89.2

Modal NOx Comparison – FTP vs. LA92



Modal NOx Comparison – FTP vs. LA92